

Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) EP 0 901 160 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:  
10.03.1999 Bulletin 1999/10

(51) Int. Cl.<sup>6</sup>: H01L 21/321

(21) Application number: 98115330.7

(22) Date of filing: 14.08.1998

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE  
Designated Extension States:  
AL LT LV MK RO SI

(30) Priority: 18.08.1997 JP 221564/97

(71) Applicant:  
MITSUBISHI GAS CHEMICAL COMPANY, INC.  
Chiyoda-ku, Tokyo (JP)

(72) Inventors:  
• Maruyama, Taketo  
Mitsubishi Gas Chem. Comp., Inc.  
Niigata-shi, Niigata-ken (JP)

• Hasemi, Ryuji  
Mitsubishi Gas Chemical Comp., Inc.  
Niigata-shi, Niigata-ken (JP)  
• Ikeda, Hidetoshi  
Mitsubishi Gas Chem. Comp., Inc.  
Niigata-shi, Niigata-ken (JP)  
• Aoyama, Tetsuo  
Mitsubishi Gas Chemical Comp., Inc.  
Niigata-shi, Niigata-ken (JP)

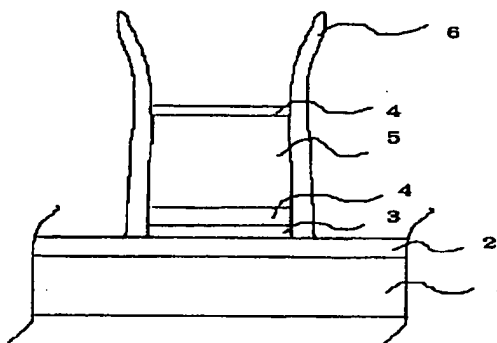
(74) Representative:  
Türk, Gille, Hrabal  
Brucknerstrasse 20  
40593 Düsseldorf (DE)

(54) Cleaning liquid for semiconductor devices

(57) A cleaning liquid for semiconductor devices comprising 0.1 to 10% by weight of a fluorine compound, 72 to 80% by weight of an organic solvent soluble in water, and the remaining amount of water.

The cleaning liquid can remove resist residues left remaining after dry etching and ashing in the wiring step in the production of semiconductor integrated circuits rapidly and completely at a low temperature and does not corrode wiring materials.

F i g . 1



EP 0 901 160 A2

## Description

BACKGROUND OF THE INVENTION

## 1. Field of the Invention

[0001] The present invention relates to a cleaning liquid for semiconductor devices used in the process for producing semiconductor integrated circuits, and more particularly to a cleaning liquid for semiconductor devices used for removal of resist residues left remaining after dry etching.

## 2. Description of the Related Arts

[0002] Semiconductor integrated circuits are produced in accordance with the following procedures: an inorganic substrate is coated with a photoresist; patterns are formed on the photoresist by exposure of light followed by development; the patterned photoresist is used as a mask, and portions of the inorganic substrate not masked by the photoresist are dry etched with a reactive gas and then ashed; and resist residues (protective deposit films) left remaining on the inorganic substrate are removed from the inorganic substrate. A gas containing chlorine is generally used to dry etch the photoresist coated on the inorganic substrate. Resist residues are formed by the reaction of the photoresist with the reactive gas containing chlorine during the dry etching. Protective deposit films left remaining on the inorganic substrate cause disconnection and abnormal wiring, and various troubles arise. Therefore, complete removal of the protective deposit films is desired.

[0003] Alkaline cleaning liquids have heretofore been used as the liquid for removing resist residues. Examples of the alkaline cleaning liquid include a cleaning liquid comprising an addition product of ethylene oxide to an alkanolamine or a polyalkylenepolyamine, a sulfone compound, and a glycol monoalkyl ether (Japanese Patent Application Laid-Open No. Showa 62(1987)-49355) and a cleaning liquid comprising dimethylsulfoxide as the main component and a diethylene glycol monoalkyl ether and an organic hydroxy compound containing nitrogen as other components (Japanese Patent Application Laid-Open No. Showa 64(1989)-42653. However, the above cleaning liquids become alkaline during the use because of dissociation of the amine caused by absorbed water. When cleaning is conducted with water without using an organic solvent such as an alcohol after the removal of the resist residues, water used in the cleaning becomes alkaline. This accelerates corrosion of aluminum which is frequently used as the wiring material in the formation of fine circuits. Therefore, the above cleaning liquids are not preferable for use in the recent working of fine structures which require rigorous precision.

[0004] Cleaning liquids for semiconductor devices comprising an aqueous solution containing a fluorine compound, an organic solvent, and a corrosion inhibitor have recently been used as a cleaning liquid which shows an excellent ability to remove resist residues and can be used conveniently (Japanese Patent Application Laid-Open Nos. Heisei 7(1995)-201794 and Heisei 8(1996)-20205).

[0005] However, the condition of dry etching continues to become severer. For example, a gas containing fluorine is added to a gas containing chlorine for dry etching, and a high density plasma is used for dry etching. This change in the condition causes further chemical change in the resist residues, and the above cleaning liquids for semiconductor devices cannot achieve complete removal of the resist residues.

[0006] When an alkali metal such as sodium and potassium is present in a cleaning liquid, the metal is adsorbed on the surface of a substrate. When a device is formed on the substrate in this condition, a problem arises in that the properties of the device tend to deteriorate even at a low temperature because of the presence of mobile ions which are derived from the alkali metal and move within the device, and thus yield of the device tends to decrease.

[0007] As described above, a cleaning liquid which can remove resist residues left remaining after dry etching and ashing in the wiring step in the production of semiconductor integrated circuits rapidly and completely at a low temperature and does not corrode wiring materials has been desired.

SUMMARY OF THE INVENTION

[0008] As the result of extensive studies by the present inventors to solve the above problems of the conventional technologies, it was found that resist residues which were left remaining after dry etching with a reactive gas and ashing could be removed very easily without corrosion of wiring materials when an aqueous solution comprising a fluorine compound and a large amount of a solvent soluble in water was used as the cleaning liquid for semiconductor devices.

The present invention has been completed on the basis of this knowledge.

[0009] Accordingly, the present invention provides a cleaning liquid for semiconductor devices comprising 0.1 to 10% by weight of a fluorine compound, 72 to 80% by weight of an organic solvent soluble in water, and the remaining amount of water.

**BRIEF DESCRIPTION OF THE DRAWING****[0010]**

5 Figure 1 shows a section view of a semiconductor device which has been dry etched using a resist film as a mask to form a circuit of an aluminum alloy (Al-Si-Cu) and ashed with oxygen plasma.

- 1 A silicon substrate
- 2 An oxide film
- 10 3 Titanium
- 4 Titanium nitride
- 5 A circuit of an aluminum alloy (Al-Si-Cu)
- 6 A resist residue

**15 DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[0011] The fluorine compound is a compound represented by  $R_4NF$ , wherein R represents hydrogen atom or an alkyl group having 1 to 4 carbon atoms. Examples of the fluorine compound include ammonium fluoride, hydrofluoric acid, acidic ammonium fluoride, hydrogen fluoride salt of methylamine, hydrogen fluoride salt of ethylamine, hydrogen fluoride salt of propylamine, tetramethylammonium fluoride, and tetraethylammonium fluoride. Among these compounds, ammonium fluoride and tetramethylammonium fluoride are preferable, and ammonium fluoride is more preferable. The fluorine compound can be used singly or as a combination of two or more compounds. The fluorine compound is used in such an amount that the concentration in the entire solution is in the range of 0.1 to 10% by weight, preferably in the range of 0.1 to 5% by weight, more preferably in the range of 0.5 to 1.5% by weight. When the amount of the fluorine compound exceeds the above range, corrosion of wiring materials such as aluminum takes place. When the amount of the fluorine compound is less than the above range, the ability of removing resist residues decreases. Therefore, such amounts are not preferable.

[0012] Examples of the organic solvent soluble in water include amides, such as formamide, monomethylformamide, dimethylformamide, acetamide, methylacetamide, dimethylacetamide, and N-methylpyrrolidone; ethers, such as ethylene glycol monomethyl ether, diethylene glycol monomethyl ether, diethylene glycol monobutyl ether, diethylene glycol dimethyl ether, and diethylene glycol diethyl ether; sulfones, such as sulfolane; sulfoxides, such as dimethylsulfoxide; and alcohols, such as methanol, ethanol, isopropanol, ethylene glycol, and glycerol. Among these organic solvents soluble in water, dimethylformamide, dimethylacetamide, N-methylpyrrolidone, and dimethylsulfoxide are preferable. The organic solvent soluble in water can be used singly or as a combination of two or more solvents. The organic solvent soluble in water is used in such an amount that the concentration in the entire solution is in the range of 72 to 80% by weight, preferably in the range of 72 to 75% by weight. When the amount of the organic solvent soluble in water is less than 72% by weight in the entire solution, corrosion of wiring materials increases. When the amount exceeds 80% by weight, the ability to remove resist residues is inferior.

[0013] The amount of water used in the present invention is not particularly limited and can be selected in accordance with the amounts of the fluorine compound and the organic solvent soluble in water.

[0014] As described above, when an alkali metal such as sodium and potassium is present in the cleaning liquid, the metal is adsorbed on the surface of the substrate, and drawbacks arise in that the properties of the device tend to deteriorate and that the yield of the device decreases. To improve the drawbacks, it is preferable that water, the fluorine compound, and the organic solvent soluble in water used in the cleaning liquid of the present invention are treated with an ion exchange membrane or an ion exchange resin in advance so that the concentration of ions of alkali metals in the cleaning liquid for semiconductor devices of the present invention is decreased to 0.5 ppm or less.

[0015] The cleaning liquid for semiconductor devices of the present invention is used to remove resist residues which are left remaining after an inorganic substrate coated with a photoresist has been dry etched with a reactive gas and then ashed with plasma. The removal of the resist residues with the cleaning liquid for semiconductor devices of the present invention can be, in general, conducted satisfactorily at a room temperature but may be conducted under heating, where necessary. As the rinse liquid used in the present invention, an alcohol, such as methyl alcohol, ethyl alcohol, and isopropanol, can be used. Ultra-pure water alone can also be used as the rinse liquid without any problem. Alternatively, a mixture of the above alcohol and ultra-pure water can be used as the rinse liquid without any problem. It is preferable that a surfactant, such as a cationic surfactant, an anionic surfactant, and nonionic surfactant, is added to the cleaning liquid of the present invention, where necessary. A corrosion inhibitor for the inorganic substrate, such as a sugar, a sugar alcohol, a polyphenol, and a quaternary ammonium salt, can be added without any problem.

[0016] Examples of the inorganic substrate to which the cleaning liquid of the present invention is applied include semiconductor wiring materials, such as silicon, a-silicon, polysilicon, films of silicon oxide, films of silicon nitride, alu-

minum, aluminum alloys, titanium, titanium-tungsten, titanium nitride, tungsten, tantalum, tantalum oxides, tantalum alloys, chromium, chromium oxides, chromium alloys, and ITO (indium tin oxides); compound semiconductors, such as gallium-arsenic, gallium-phosphorus, and indium-phosphorus; and glass substrates, such as LCD.

**[0017]** To summarize the advantages of the present invention, the cleaning liquid for semiconductor devices of the present invention can remove resist residues left remaining after dry etching with a reactive gas and ashing very easily without corrosion of wiring materials.

#### EXAMPLES

**[0018]** The present invention is described more specifically with reference to examples in the following. However, the present invention is not limited by the examples.

#### Examples 1 to 11

**[0019]** A circuit of an aluminum alloy (Al-Si-Cu) was formed by dry etching using a resist film as the mask. The formed circuit was ashed with oxygen plasma, and a semiconductor device shown in Figure 1 was prepared. In the semiconductor device, an oxide film 2 is formed on a silicon substrate 1. The aluminum alloy 5 which is the circuit material is disposed on the oxide film 2, and resist residues 6 are left remaining on both sides. Titanium 3 and titanium nitride 4 are disposed as barrier metals.

**[0020]** The semiconductor device prepared above was dipped into a cleaning liquid for semiconductor device having a composition shown in Table 1 in the condition also shown in Table 1. After the dipping, the device was rinsed with ultra-pure water and dried. Removal of the resist residues on the sides and corrosion of the surface of the aluminum alloy were examined by observation using an electron microscope (SEM). The electric property of the semiconductor device after the rinse was measured in accordance with the following method of EBIC (Electron-Beam Induced Current): The surface of a semiconductor device was scanned by an electronic beam, and the electric current flowing through the device was two-dimensionally measured and displayed as an image to detect defects in a wafer (crystal). When defects were present, electromigration (disconnection) takes place, and the electric property deteriorates. Therefore, when defects were absent, the electric property was evaluated as good, and when defects were present, the electric property was evaluated as poor. The results are shown in Table 1.

**[0021]** The results of the observation are expressed as shown in the following:

#### [Removal of resist residues]

#### **[0022]**

excellent:	completely removed
good:	nearly completely removed
fair:	a portion of the residue remained
poor:	most of the residue remained

#### [Corrosion]

#### **[0023]**

excellent:	no corrosion found
good:	little corrosion found
fair:	corrosion of a crater shape or a pit shape found
poor:	rough surfaces all over the aluminum circuit; depression of Al-Si-Cu layer observed

**[0024]** The concentration of alkali ions (Na+K) in the cleaning liquid was measured in accordance with the flameless atomic absorption spectrometry.

Table 1-1

	fluorine compound		solvent soluble in water		additive	
	compound	concn. (% by wt.)	solvent	concn. (% by wt.)	additive	concn. (% by wt.)
Example 1	ammonium fluoride	1.0	dimethylformamide	72	-	-
Example 2	ammonium fluoride	1.0	dimethylformamide	72	TMAF <sup>1)</sup>	1.0
Example 3	ammonium fluoride	1.0	N-methylpyrrolidone	74	-	-
Example 4	ammonium fluoride	1.0	N-methylpyrrolidone	72	nonionic surfactant	0.05
Example 5	ammonium fluoride	3.0	dimethylformamide	75	-	-
Example 6	ammonium fluoride	1.0	dimethylacetamide	72	-	-
Example 7	ammonium fluoride	1.0	dimethylsulfoxide	72	-	-
Example 8	tetramethylammonium fluoride	1.5	dimethylformamide	78	-	-
Example 9	ammonium fluoride	0.5	dimethylformamide	76	-	-
Example 10	ammonium fluoride	0.5	N-methylpyrrolidone	77	-	-
Example 11	ammonium fluoride	1.0	dimethylformamide	78	-	-

<sup>1)</sup>TMAF: tetramethylammonium formate

[0025]

Table 1-2

	water concn. (% by wt.)	concn. of alkali ions (ppm)	condition of dipping		removal of resist residues	corrosion of Al alloy	electric property
			temperature (°C)	time			
Example 1	27.0	0.2	23	5	excellent	excellent	good
Example 2	26.0	0.1	23	5	excellent	excellent	good
Example 3	25.0	0.2	23	5	excellent	excellent	good
Example 4	26.95	0.1	23	5	excellent	excellent	good
Example 5	22.0	0.05	23	5	excellent	good	good
Example 6	27.0	0.1	23	5	excellent	good	good
Example 7	27.0	0.2	23	5	excellent	good	good
Example 8	20.5	0.1	23	5	excellent	excellent	good
Example 9	23.5	0.05	23	10	excellent	excellent	good
Example 10	22.5	0.3	23	10	excellent	excellent	good
Example 11	21.0	0.2	23	10	excellent	excellent	good

Comparative Example 1 to 4

[0026] A semiconductor device prepared in accordance with the same procedures as those conducted in above

Examples was dipped into a cleaning liquid for semiconductor device having a composition shown in Table 2 in the condition also shown in Table 2. After the dipping, the device was rinsed with ultra-pure water and dried. Removal of the resist residues on the sides and corrosion of the surface of the aluminum alloy were examined by observation using an electron microscope (SEM). The electric property was measured in accordance with the method described above. The results are shown in Table 2.

[0027] The results of the observation by SEM are expressed in the same manner as that in Examples.

Table 2-1

	fluorine compound		solvent soluble in water		additive	
	compound	concn. (% by wt.)	solvent	concn. (% by wt.)	additive	concn. (% by wt.)
Comparative Example 1	ammonium fluoride	1.0	-	-	-	-
Comparative Example 2	-	-	dimethylformamide	72	-	-
Comparative Example 3	ammonium fluoride	0.05	dimethylformamide	72	-	-
Comparative Example 4	ammonium fluoride	0.03	dimethylacetamide	90	-	-

Table 2-2

	water concn. (% by wt.)	concn. of alkali ions (ppm)	condition of dipping		removal of resist residues	corrosion of Al alloy	electric property
			temperature (°C)	time			
Comparative Example 1	99.0	0.5	23	5	fair	poor	poor
Comparative Example 2	28.0	0.7	23	5	poor	excellent	poor
Comparative Example 3	27.95	0.6	23	5	fair	good	poor
Comparative Example 4	9.97	0.9	23	5	fair	good	poor

#### Claims

1. A cleaning liquid for semiconductor devices comprising 0.1 to 10% by weight of a fluorine compound, 72 to 80% by weight of an organic solvent soluble in water, and the remaining amount of water.
2. A cleaning liquid according to Claim 1, wherein the fluorine compound is a compound represented by  $R_4NF$ , R representing hydrogen atom or an alkyl group having 1 to 4 carbon atoms.
3. A cleaning liquid according to Claim 1, wherein the fluorine compound is ammonium fluoride or tetramethylammonium fluoride.
4. A cleaning liquid according to Claim 1, which comprises the fluorine compound in an amount of 0.5 to 1.5% by weight.

5. A cleaning liquid according to Claim 1, wherein the organic solvent soluble in water is at least one solvent selected from the group consisting of dimethylformamide, dimethylacetamide, dimethylsulfoxide, and N-methylpyrrolidone.

5

10

15

20

25

30

35

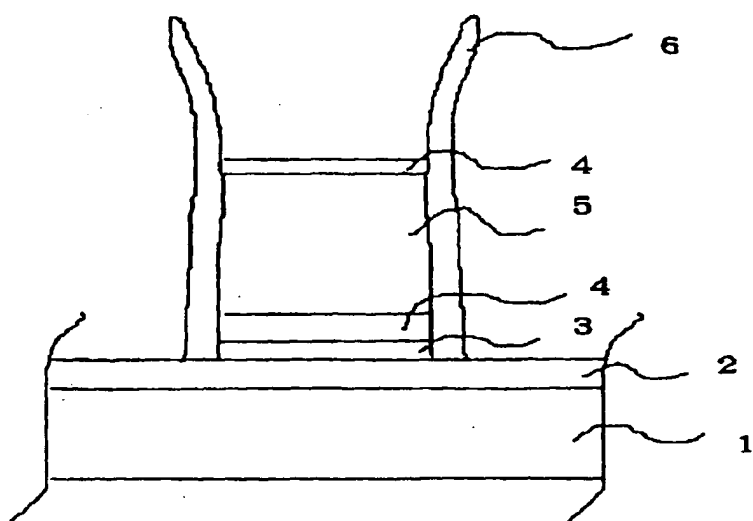
40

45

50

55

F i g . 1





(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 901 160 A3

(12)

## EUROPEAN PATENT APPLICATION

(88) Date of publication A3:  
27.09.2000 Bulletin 2000/39

(51) Int. Cl.<sup>7</sup>: H01L 21/321

(43) Date of publication A2:  
10.03.1999 Bulletin 1999/10

(21) Application number: 98115330.7

(22) Date of filing: 14.08.1998

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE  
Designated Extension States:  
AL LT LV MK RO SI

(30) Priority: 18.08.1997 JP 22156497

(71) Applicant:  
MITSUBISHI GAS CHEMICAL COMPANY, INC.  
Chiyoda-ku, Tokyo (JP)

(72) Inventors:  
• Maruyama, Taketo  
Mitsubishi Gas Chem. Comp., Inc.  
Niigata-shi, Niigata-ken (JP)

• Hasemi, Ryuji  
Mitsubishi Gas Chemical Comp., Inc.  
Niigata-shi, Niigata-ken (JP)  
• Ikeda, Hidetoshi  
Mitsubishi Gas Chem. Comp., Inc.  
Niigata-shi, Niigata-ken (JP)  
• Aoyama, Tetsuo  
Mitsubishi Gas Chemical Comp., Inc.  
Niigata-shi, Niigata-ken (JP)

(74) Representative:  
Gille Hrabal Struck Neidlein Prop Roos  
Patentanwälte  
Brucknerstrasse 20  
40593 Düsseldorf (DE)

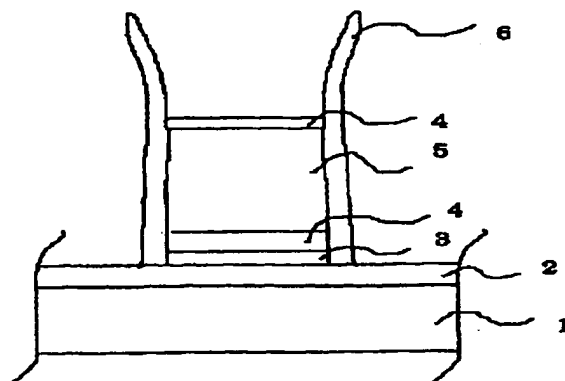
### (54) Cleaning liquid for semiconductor devices

(57) A cleaning liquid for semiconductor devices comprising 0.1 to 10% by weight of a fluorine compound, 72 to 80% by weight of an organic solvent soluble in water, and the remaining amount of water.

The cleaning liquid can remove resist residues left

remaining after dry etching and ashing in the wiring step in the production of semiconductor integrated circuits rapidly and completely at a low temperature and does not corrode wiring materials.

F i g . 1



EP 0 901 160 A3



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 98 11 5330

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Clg)
X	US 5 478 436 A (WINEBARGER PAUL M ET AL) 26 December 1995 (1995-12-26) * column 1, line 48 - column 4, line 16 *	1-3,5	H01L21/321
X	EP 0 773 480 A (TOKYO OHKA KOGYO CO LTD) 14 May 1997 (1997-05-14) * page 2, line 50 - page 4, line 4; example 8 *	1-5	
E	JP 11 016882 A (TORAY FINE CHEM CO LTD) 22 January 1999 (1999-01-22) * paragraph '0007! - paragraph '0019!; examples *	1-5	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Clg)  H01L G03F
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>7 August 2000</b>	Examiner <b>Köpf, C</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04001)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 98 11 5330

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

07-08-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5478436 A	26-12-1995	NONE	
EP 0773480 A	14-05-1997	JP 9197681 A	31-07-1997
		US 5905063 A	18-05-1999
		US 5792274 A	11-08-1998
JP 11016882 A	22-01-1999	NONE	



European Patent  
Office

**SUPPLEMENTARY  
EUROPEAN SEARCH REPORT**

Application Number  
**EP 00 90 4197**

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 827 188 A (MITSUBISHI GAS CHEMICAL CO) 4 March 1998 (1998-03-04)	1,3-5, 10,11, 14-17	C11D9/04
Y	* example 4 *	2,6-9, 12,13	
	* page 9, line 19 - line 20 *		
Y,D	US 5 571 447 A (WARD IRL E. ET AL) 5 November 1996 (1996-11-05) * column 3, line 8 - line 10 * * column 3, line 34 - line 55 * * column 4, line 1 - line 5 * * claim 4 *	2,6-9, 12,13	
A	WO 98 30667 A (ADVANCED CHEM SYSTEMS INT) 16 July 1998 (1998-07-16) ? * claims *	1-17	
P,A	EP 0 901 160 A (MITSUBISHI GAS CHEMICAL CO) 10 March 1999 (1999-03-10) ? * claims; tables 1-1 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			C11D H01L
The supplementary search report has been based on the last set of claims valid and available at the start of the search.			
Place of search <b>MUNICH</b>		Date of completion of the search <b>14 August 2002</b>	Examiner <b>Loloiu, C</b>
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 90 4197

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-08-2002

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0827188	A	04-03-1998	JP 10055993 A	24-02-1998
			EP 0827188 A2	04-03-1998
			SG 60096 A1	22-02-1999
			US 5972862 A	26-10-1999
<hr/>				
US 5571447	A	05-11-1996	NONE	
<hr/>				
WO 9830667	A	16-07-1998	US 6224785 B1	01-05-2001
			JP 2001508239 T	19-06-2001
			WO 9830667 A1	16-07-1998
			US 2001050350 A1	13-12-2001
<hr/>				
EP 0901160	A	10-03-1999	JP 11067632 A	09-03-1999
			EP 0901160 A2	10-03-1999
			US 5962385 A	05-10-1999
<hr/>				

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US00/00116

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :C11D 9/04

US CL :510/175, 176

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 510/175, 176

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
DERWENT, STN

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US 5,972,862 A (TORRI et al) 26 October 1999, col. 12, lines 50-66.	1,3,5,8, 10-12, 14-16
A	US 5,698,503 A (WARD et al) 16 December 1997, col. 5, lines 15-27.	1-17

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Z" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search  
18 APRIL 2000

Date of mailing of the international search report  
25 MAY 2000

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231  
Facsimile No. (703) 305-3230

Authorized officer  
GREGORY WEBB  
Telephone No. (703) 308-0661